SECURITY MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.
Separate page printouts MUST be marked accordingly.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

2 Feb 55

WADC TECHNICAL REPORT 54-277

ICING-INTENSITY DATA FOR THE 1953-54 SEASON

B. J. Brown

Aeronautical Icing Research Laboratories
Smith, Hinchman & Grylls, Inc.

June 1954

WRIGHT AIR DEVELOPMENT CENTER

REPORT NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The information furnished herewith is made available for study upon the understanding that the Government's proprietary interests in and relating thereto shall not be impaired. It is desired that the Judge Advocate Office, WCJ, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, be promptly notified of any apparent conflict between the Government's proprietary interests and those of others.

The U. S. Government is absolved from any litigation which may ensue from the contractor's infringing on the foreign patent rights which may be involved.

(18) (19) WADC T[redacted] R[redacted]-54-277

(6) ICING-INTENSITY DATA FOR THE 1953-54 SEASON.

(9) Technical rept.,

(10) B. J. Brown.

(5) Aeronautical Icing Research Lab~~oratories~~
Smith, Hinchman & Grylls, Inc.
Ypsilanti, Mich.

(11) June [redacted]54, (12) 26 p.

[redacted]

(15) [redacted] AF33(600)-8114

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

7950

FOREWORD

This report was prepared by the Aeronautical Icing Research Laboratories, of Smith, Hinchman & Grylls, Inc., in partial fulfillment of the requirements of Contract AF33(600)-8114. The Aeronautical Icing Research Laboratories are performing research and development work on aircraft-icing problems under the research and development contract identified by Research and Development Order No. 208-19. This program is administered under the direction of the Programs Unit, All-Weather Branch, Directorate of Flight and All-Weather Testing, Wright Air Development Center, with Mr. R. J. Hawn as the Project Engineer.

Capts W. E. Archer and R. L. Schumacher, of the Wright Air Development Center, were the pilots of the airplane utilized to compile the icing data presented in the report.

ABSTRACT

The meteorological data obtained under natural-icing conditions ~~by the Aeronautical Icing Research Laboratories, of Smith, Hinchman & Grylls, Inc.,~~ at Willow Run, Michigan, and at Mt. Washington, New Hampshire, during the 1953-54 icing season, are presented. A total of 25 icing flights were made with a B-24 airplane. During these icing flights, 156 icing-intensity measurements were obtained by the rotating-multicylinder method. A total of 84 rotating-multicylinder runs were conducted at Mt. Washington.

The data presented consist of liquid-water content, mean-effective droplet diameter, droplet-distribution type, free-air temperature, pressure altitude, true air speed, type of cloud, and geographical location. The range of the meteorological conditions measured during the season is as follows: liquid-water content, 0.04 to 0.95 gm/m^3; mean-effective droplet diameter, 5 to 36 microns; free-air temperature, -3° to +31°F; and pressure altitude, 3850 to 7550 feet.

Frequency-of-occurrence curves for liquid-water content and mean-effective droplet diameter are presented.

PUBLICATION REVIEW

The publication of this report does not constitute approval by the Air Force of the findings or the conclusions contained therein. It is published only for the exchange and stimulation of ideas.

H. B. Manson, Jr.
Colonel, USAF
Director of Flight and All-Weather Testing

INTRODUCTION

This report contains data on the measurement of the meteorological variables encountered during natural-icing conditions. These data were obtained by the Aeronautical Icing Research Laboratories, of Smith, Hinchman & Grylls, Inc., at Willow Run, Michigan, and at the Summit of Mt. Washington, New Hampshire.

At Willow Run, actual aircraft flights were used in the collection of these data. On Mt. Washington, there were two exposure sites: (a) the Jet-Engine Test Facility, and (b) the Yankee Exposure Site.

Icing-intensity measurements were obtained at both laboratories by means of rotating-multicylinder units. From these measurements, it is possible to determine the meteorological variables encountered during icing conditions, i.e., liquid-water content, mean-effective droplet diameter, and droplet-size distribution.

The range of meteorological conditions encountered during the 1953-54 icing season are given in the following tabulation:

	Test Flights		Mt. Washington	
	Max.	Min.	Max.	Min.
Liquid-Water Content, gm/m^3	0.75	0.04	0.95	0.04
Mean-Droplet Size, microns	36	6	32	5
Ambient-Air Temperature, °F	+27	+1	+31	-3
Pressure Altitude, ft	7550	3850	-	-
Geographic Altitude, ft	-	-	6300	6300

This report has been divided into two parts, the first part containing the icing-intensity data obtained during icing flights at Willow Run, Michigan, and the second part summarizing the icing-intensity data obtained at the Summit of Mt. Washington, New Hampshire.

ICING-INTENSITY DATA FOR THE 1953-54 SEASON

FLIGHT ICING-INTENSITY MEASUREMENTS (Willow Run)

Equipment and Procedure. The rotating-multicylinder data from AIRL at Willow Run were obtained during flights through natural-icing conditions. The aircraft used for all of these flights was an EB-24M airplane, equipped with a thermal anti-icing system.

The rotating-multicylinder array consists of a six-cylinder unit having diameters of 1/8, 5/16, 1/2, 1-1/4, 1-3/4, and 3 inches. The exposed length of the 1/8-inch diameter cylinder is 12.7 centimeters and the remaining five have exposed lengths of 10 centimeters each. The meteorolgoical data were calculated by the method described in Reference 1.

All of the flight meteorological data were obtained at or below pressure altitudes of 7550 feet. Flight procedures varied with existing weather conditions, traffic-control problems, and the requirements of concurrent engineering flight projects.

Results and Discussion. Table 1 (page 4) presents a summary of the flight meteorological data for the 1953-54 icing season. A total of 25 flights were conducted during which icing conditions were encountered, and the total number of rotating-multicylinder runs was 156. In 23 of the 156 multicylinder runs the experimental-data curves could not be matched with any of the theoretical $K\emptyset$ curves and the data could not be reduced. This is usually caused by "blowoff", exposure of cylinders in conditions of very low liquid-water contents, or inaccuracies in measuring or weighing the cylinders. The 23 multicylinder runs which could not be matched with the theoretical $K\emptyset$ curves are labeled as such in the Remarks column of Table 1.

The multicylinder data were obtained primarily for engineering projects which required only the measurement of the severity of the icing conditions. No information was secured pertaining to cloud depths or the extent of the icing conditions. Therefore, the data presented in Table 1 are useful only from a statistical point of view to show the range and frequency of icing intensity. For this reason, the extent of the icing intensity in terms of liquid-water content and mean-effective droplet diameter for this season is shown by means of cumulative-frequency curves of the 133 satisfactory rotating-multicylinder runs. Figure 1 shows the cumulative-frequency curve of the liquid-water content. It indicates that 89% of the rotating-multicylinder runs were made in clouds with water concentrations of less than 0.50 gm/m^3. Figure 2 shows the cumulative-frequency curve of the mean-effective droplet diameter. It indicates that 88% of the rotating-multicylinder runs produced droplet diameters of less than 15 microns.

The maximum mean-effective droplet diameter measured for the 1953-54 icing season was 36 microns.

Figure 3 is a plot of liquid-water content vs. droplet diameter for the 133 multicylinder runs. The envelope of the data points indicates that beyond 0.34 gm/m^3 there is an apparent decrease in droplet size with increase in liquid-water content.

Figure 4 is a plot of liquid-water content vs. temperature. This curve shows that most of the multicylinder runs were obtained with temperatures ranging from 10° to 25°F. Above 25°F, "blowoff" occurs to such a degree that reliable multicylinder runs can be obtained only when small liquid-water contents are encountered.

PROJECT SUMMIT DATA (Mt. Washington)

Equipment and Procedure. The natural-icing data presented in this part of the report were obtained by means of rotating-multicylinder units installed on the North and South Test Stands of the Jet-Engine Test Facility and at the Yankee Exposure Site.

The rotating-multicylinder unit consists of five cylinders with diameters of 1/8, 1/2, 1-1/4, 2, and 3 inches. The length of each cylinder is 6 centimeters, with the exception of the 1/8-inch cylinder which is 8 centimeters long.

Results and Discussion. The total number of multicylinder runs made at Mt. Washington for the 1953-54 season was 84. For those multicylinder runs where the data were unreliable and the liquid-water content was estimated, a notation is included in the Remarks column of Table 2.

Figures 5 and 6 are cumulative-frequency curves of 79 rotating-multicylinder observations taken from Table 2. Figure 5 indicates that 83% of the measured liquid-water contents were below 0.50 gm/m^3. The maximum liquid-water content was 0.95 gm/m^3. Figure 6 shows the cumulative-frequency curve of the mean-effective droplet diameter. It indicates that 79% of the observations were made in clouds with a mean-effective droplet diameter of 15 microns or less. The maximum mean-effective droplet diameter measured in the 1953-54 season was 32 microns.

REFERENCE

1. Downie, C. S. The Rotating-Cylinder Method for Obtaining Icing-Intensity Data. AIRL No. 48-3-2P, 1948.

TABLE 1

SUMMARY OF FLIGHT ICING-INTENSITY DATA OBTAINED
BY THE ROTATING-MULTICYLINDER METHOD DURING
THE 1953-54 ICING SEASON

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESS-URE ALTI-TUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m³)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRI-BUTION	CLOUD TYPE	LOCATION	REMARKS
1953											
12-11	1	1509	178	879	25				Cum.	25 mi. NE of Traverse City	Clear ice *
	1	1517	176	873	23	0.56	6	H	↓	30 mi. SW of Pellston	Clear ice
	1	1525	176	874	23	0.40	11	D	↓	Over Pellston	↓
	1	1518	170	872	19	0.37	10	C	↓	25 mi. N. of Pellston	
	1	1520	171	873	21				↓	15 mi. S. Sault Ste. Marie	Clear ice *
	1	1555	171	872	21	0.55	14	G	↓	Over Sault Ste. Marie	Clear ice
	1	1615	173	852	21	0.75	12	J	↓	Over Sault Ste. Marie	↓
	1	1627	173	847	18				↓	35 mi. SW of Sault Ste. Marie	Clear ice *
	1	1635	189	855	21	0.34	14	A	↓	10 mi. N. of Pellston	Clear ice
	1	1643	182	862	21	0.29	11	A	↓	5 mi. S. of Pellston	↓
	1	1650	180	865	21	0.24	12	A	↓	15 mi. N. of Traverse City	
	1	1700	184	864	21	0.38	9	E	↓	15 mi. N. of Traverse City	↓

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1953 12-28	1	1135	185	840	18	0.14	9	J	Strat	30 mi. NW of Willow Run	Clear ice w/snow
	1	1142	180	827	18	0.21	11	J		Over Lansing	
	1	1150	183	785	16	0.30	13	J		15 mi. W. of Lansing	Clear ice
	1	1156	176	830	16	0.50	12	J		10 mi. E. of Grand Rapids	
	1	1204	173	830	14	0.67	11	J		Over Grand Rapids	
	1	1212	174	827	14	0.47	11	J		15 mi. N. of Grand Rapids	
	1	1235	175	832	14	0.16	14	C		30 mi. N. of Grand Rapids	
	1	1240	174	832	14	0.28	14	J		10 mi. N. of Grand Rapids	
	1	1245	174	829	14	0.21	7	J		Over Grand Rapids	
	1	1251	174	829	14	0.18	11	A		Over Grand Rapids	
	1	1256	188	829	16	0.33	7	J		20 mi. W. of Grand Rapids	
	1	1304	174	828	16	0.54	11	J		10 mi. W. of Lansing	
1954 1-5	1	1352	178	854	18	0.34	13	J	Strat	5 mi. N. of Traverse City	Clear ice
	1	1358	178	850	18	0.08	6	J		20 mi. N. of Traverse City	
	1	1420	176	865	16	0.51	9	J		Over Pellston	
	1	1425	166	860	16	0.41	7	J		Over Pellston	

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
1-5	1	1431	171	860	16	0.22	10	J	Strat	Over Pellston	Clear ice
	1	1437	176	862	16	0.26	9	J	↓	Over Pellston	↓
	1	1446	177	863	18	0.04	12	A		Over Pellston	
	1	1452	196	872	18	0.19	10	J		Over Pellston	
	1	1457	174	872	18					Over Pellston	Clear ice *
	1	1503	173	860	16				↓	Over Pellston	↓
1-14	1	1020	176	786	18	0.33	10	H	Strat	Over Lansing	Clear ice
	1	1028	183	785	18	0.38	12	H		25 mi. W. of Lansing	
	1	1036	181	790	16	0.55	6	J		15 mi. E. of Grand Rapids	
	1	1046	182	814	18	0.25	13	B		5 mi. W. of Grand Rapids	
	1	1054	181	810	18	0.23	16	A		10 mi. E. of Muskegon	
	1	1108	190	835	18	0.07	11	A		15 mi. E. of Muskegon	
	1	1117	182	813	19	0.29	8	G		5 mi. E. of Grand Rapids	
	1	1126	189	813	19	0.09	7	D		30 mi. E. of Grand Rapids	
	1	1154	179	840	19	0.23	7	J		15 mi. W. of Lansing	
	1	1155	192	840	19	0.19	11	J		45 mi. W. of Lansing	
	1	1201	184	818	21	0.17	7	H	↓	12 mi. E. of Grand Rapids	↓

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
1-14	1	1209	192	822	19	0.22	7	J	Strat.	30 mi. E. of Grand Rapids	Clear ice
1-18	1	1342	178	875	19	0.13	21	J	St. Cum.	10 mi. SE of Flint	
	1	1353	173	875	18	0.42	11	J		Over Flint	
	1	1354	174	860	16					15 mi. N. of Flint	Clear ice *
	1	1440	174	845	10	0.36	8	H		20 mi. E. of Grand Rapids	
	1	1445	175	841	10	0.42	12	B		10 mi. E. of Grand Rapids	Rime & clear
	1	1452	173	841	10	0.68	7	G		10 mi. W. of Grand Rapids	Rime
	1	1458	172	838	9	0.32	11	A		20 mi. W. of Grand Rapids	
	1	1509	182	847	10	0.14	11	B		6 mi. W. of Muskegon	Clear ice
	1	1515	176	847	10	0.54	11	D		6 mi. W. of Grand Rapids	Rime ice
	1	1520	167	845	10	0.66	13	B		15 mi. SE of Grand Rapids	
	1	1525	177	843	10	0.52	15	A		20 mi. E. of Grand Rapids	Clear ice
2-5	1	1041	182	807	12	0.32	25	B	St. Cum.	30 mi. E. of Lansing	Rime ice
	1	1049	187	814	12	0.17	13	J		Over Lansing	
	1	1124	180	796	9	0.31	36	J		10 mi. E. of Grand Rapids	

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
2-5	1	1200	174	840	10	0.18	36	J	St. Cum.	10 mi. S. of Cadillac	Rime ice
	1	1208	183	840	10	0.08	21	J	↓	Over Cadillac	↓
	1	1221	186	836	10	0.30	26	J	↓	12 mi. N. of Traverse City	↓
	1	1231	179	838	12	0.11	18	J	↓	45 mi. N. of Traverse City	↓
	1	1240	183	835	12	0.40	13	J	↓	5 mi. S. of Pellston	↓
	1	1246	176	837	12	0.42	18	J	↓	Over Pellston	↓
	1	1258	174	837	10				↓	25 mi. SW of Pellston	Rime ice *
	1	1309	185	838	10				↓	5 mi. N. of Traverse City	↓
	1	1317	176	838	10				↓	25 mi. SE of Traverse City	↓
2-8	1	1050	175	862	19				St. Cum.	30 mi. S. of Lansing	Clear ice *
	1	1101	188	895	23				↓	20 mi. N. of Flint	↓
	1	1133	192	860	21	0.14	9	A	↓	5 mi. S. of Gladwin	Clear ice
	1	1143	189	860	21	0.11	12	A	↓	10 mi. N. of Gladwin	Clear & snow
	1	1153	180	860	19	0.32	13	A	↓	35 mi. N. of Gladwin	Clear ice
	1	1200	181	860	19	0.37	12	A	↓	20 mi. S. of Traverse City	↓

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
2-8	1	1209	179	860	18	0.18	12	A	St. Cum.	Over Traverse City	Clear ice
	1	1220	182	875	18	0.14	9	B	↓	5 mi. N. of Traverse City	↓
	1	1228	185	858	18	0.38	10	B	↓	5 mi. SE of Traverse City	↓
	1	1234	181	862	19	0.22	11	A	↓	30 mi. SE of Traverse City	↓
	1	1243	189	870	21	0.18	11	B	↓	15 mi. N. of Gladwin	↓
	1	1255	184	867	23				↓	15 mi. N. of Saginaw	Clear & snow *
2-10	1	1230	188	844	16				St. Cum.	10 mi. S. of Pellston	Rime *
	1	1356	190	825	10				↓	25 mi. N. of Traverse City	↓
	1	1410	190	815	10	0.30	11	D	↓	10 mi. N. of Traverse City	Rime
	1	1214	184	815	12				↓	15 mi. S. of Traverse City	Rime *
2-24	1	1226	172	860	18	0.10	11	A	St. Cum.	Over Flint	Rime
	1	1244	174	850	18	0.30	7	H	↓	20 mi. S. of Saginaw	↓
	1	1255	179	834	16	0.23	13	C	↓	12 mi. N. of Saginaw	↓
	1	1300	176	834	15	0.56	14	C	↓	10 mi. S. of Gladwin	↓

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
2-24	1	1310	168	833	14	0.51	14	B	St. Cum.	15 mi. N. of Gladwin	Rime
	1	1315	168	833	14	0.54	14	A	↓	40 mi. S. of Traverse City	↓
	1	1322	168	833	14	0.43	16	B		15 mi. S. of Traverse City	
	1	1326	174	833	14	0.47	10	H		5 mi. SE of Traverse City	
	1	1331	174	834	15	0.54	11	H		Over Traverse City	
	1	1337	174	834	15	0.48	11	H		7 mi. SE of Traverse City	
	1	1341	174	834	15	0.37	12	F		22 mi. SE of Traverse City	
	1	1345	171	834	15	0.57	13	D		25 mi. SE of Traverse City	
3-2	1	1107	184	887	12	0.12	9	A	St. Cum.	25 mi. S. of Traverse City	
3-23	1	1150	172	873	23	0.35	7	H	St. Cum.	30 mi. W. of Clear Creek, Canada	Clear
	1	1210	185	898	25				↓	Over Clear Creek, Canada	Clear *

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954 3-23	1	1223	177	905	27	0.28	9	G	St. Cum.	20 mi. SW of Clear Creek, Canada	Clear
	1	1232	172	898	25	0.24	8	C	↓	5 mi. E. of Chatham, Ont.	↓
	1	1237	177	895	25	0.21	11	A	↓	12 mi. E. of Chatham, Ont.	↓
3-26	1	1016	178	802	10	0.35	13	C	St. Cum.	15 mi. W. of Lansing	Rime
	1	1020	176	811	14	0.18	7	G	↓	35 mi. W. of Lansing	↓
	1	1035	165	826	14	0.22	14	A	↓	15 mi. N. of Grand Rapids	↓
	1	1051	190	776	10	0.15	10	A	↓	60 mi. N. of Grand Rapids	↓
	1	1058	187	785	10	0.30	23	C	↓	20 mi. S. of Cadillac	↓
	1	1109	184	785	10	0.10	19	F	↓	10 mi. S. of Cadillac	↓
	1	1126	179	836	10	0.28	13	B	↓	20 mi. NE of Traverse City	↓
	1	1137	183	845	10	0.44	10	J	↓	20 mi. S. of Pellston	Rime & snow
	1	1150	185	840	10	0.19	16	B	↓	20 mi. SW of Pellston	↓

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
3-26	1	1200	181	843	10	0.29	15	B	St. Cum.	20 mi. NW of Traverse City	Rime
	1	1206	183	843	10	0.20	11	C	↓	10 mi. NW of Traverse City	↓
	1	1212	178	842	12	0.46	6	H	↓	15 mi. SE of Traverse City	↓
4-2	1	1205	176	843	23				St. Cum.	15 mi. N. of Flint	Clear *
	1	1245	184	845	23				↓	20 mi. NE of Grand Rapids	↓
4-16	1	1134	172	862	21				St. Cum.	5 mi. NW of Traverse City	Clear *
	1	1142	171	862	23	0.32	11	J	↓	30 mi. NW of Traverse City	Clear
	1	1152	173	857	21	0.15	15	E	↓	10 mi. SW of Pellston	↓
	1	1206	185	857	21	0.38	11	J	↓	40 mi. N. of Pellston	↓
	1	1213	180	857	21	0.13	16	J	↓	20 mi. S. of Sault Ste. Marie	↓
	1	1219	183	857	19	0.36	12	H	↓	Over Sault Ste. Marie	↓
	1	1226	178	857	21	0.23	11	H	↓	5 mi. S. of Sault Ste. Marie	↓

* Unable to match KØ curve

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954 4-16	1	1246	181	854	21				St. Cum.	Over Pellston	Clear *
	1	1252	178	851	21	0.13	9	J		25 mi. SW of Pellston	Clear
	1	1258	180	857	21	0.23	10	J		40 mi. SW of Pellston	
	1	1303	185	857	23	0.15	9	G		12 mi. N. of Traverse City	
	1	1309	186	860	23					Over Traverse City	Clear *
5-3	1	1047	177	858	19				St. Cum.	5 mi. N. of Flint	
	1	1156	171	858	19	0.38	12	C		5 mi. S. of Saginaw	
	1	1103	169	851	18	0.46	12	D		10 mi. N. of Saginaw	
	1	1109	167	851	18	0.40	13	D		15 mi. S. of Gladwin	
	1	1120	176	842	12	0.33	10	G		15 mi. N. of Gladwin	Rime & snow
	1	1127	183	845	14	0.50	8	H		35 mi. N. of Gladwin	
	1	1135	177	851	14	0.40	8	H		20 mi. SE of Traverse City	
	1	1149	170	850	14	0.46	9	H		20 mi. N. of Traverse City	

* Unable to match KØ curve

WADC TR 54-277

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m³)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954											
5-3	1	1157	178	846	16	0.47	10	H	St. Cum.	15 mi. S. of Pellston	Rime & snow
5-3	2	1532	184	832	12	0.15	10	H	St. Cum.	20 mi. W. of Kinross	Rime & snow
		1540	182	825	10	0.16	13	J	↓	15 mi. E. of Grand Rapids	↓
5-5	1	1202	187	802	10	0.32	9	A	St. Cum.	10 mi. E. of Grand Rapids	Rime
	1	1256	189	775	7	0.24	13	C	↓	Over Saginaw	Rime & snow
	1	1332	185	774	1	0.14	22	A	↓	Over Traverse City	Rime
	1	1341	175	765	1	0.49	13	J	↓	Over Traverse City	↓
5-7	1	1131	194	862	18	0.26	10	C	St. Cum.	15 mi. SE of Traverse City	Clear
	1	1135	192	865	18	0.42	9	F	↓	Over Traverse City	↓
	1	1142	181	869	19	0.21	10	C	↓	15 mi. NW of Traverse City	↓
	1	1151	175	859	18	0.22	10	A	↓	20 mi. SW of Pellston	↓
	1	1159	183	806	18	0.16	12	A	↓	20 mi. N. of Pellston	Clear & snow
	1	1212	193	812	18	0.24	7	J	↓	40 mi. N. of Pellston	Clear

TABLE 1 (Continued)

DATE	FLT	TIME (EST)	TRUE AIR SPEED (mph)	PRESSURE ALTITUDE (ft)	TEMP (°F)	LIQUID-WATER CONTENT (gm/m^3)	MEAN-EFFECTIVE DROPLET DIAMETER (microns)	DROP-SIZE DISTRIBUTION	CLOUD TYPE	LOCATION	REMARKS
1954 5-7	1	1220	182	815	19	0.66	10	J	St. Cum.	10 mi. S. of Sault Ste. Marie	Clear
	1	1238	188	818	19	0.29	7	J		20 mi. N. of Pellston	
	1	1251	180	868	19	0.26	11	B		Over Pellston	
	1	1259	171	840	18	0.39	14	C		25 mi. S. of Pellston	
	1	1305	183	821	14					15 mi. N. of Traverse City	Clear *
	1	1312	183	838	14	0.31	13	B		10 mi. N. of Traverse City	Clear

* Unable to match KØ curve

TABLE 2

SUMMARY OF PROJECT SUMMIT ICING-INTENSITY DATA
OBTAINED BY ROTATING-MULTICYLINDER METHOD
MT. WASHINGTON, N.H.
ALTITUDE 6300 FT.

Natural Icing
1953-54 Icing Season

DATE	TEST STAND	TEMP (°F)	LWC (gm/m³)	DROP DIAMETER (microns)	DIST TYPE	REMARKS
1953						
10-25	S	28	0.10			LWC Estimated, Clear
11-4	S	13	0.11	9	C	Rime
	S	13	0.10	8	E	Rime
11-9	Y	18	0.58	9	A	Rime
	S	18	0.32	9	B	Rime
	S	18	0.35	11	A	Rime
11-15	N	27	0.54	13	C	Clear
	N	27	0.61	15	B	Clear
11-30	N	15	0.21	9	A	Rime
12-10	N	17	0.37	9	C	Clear
	N	17	0.38	12	B	Clear
12-13	N	12	0.28	9	A	Rime
	N	12	0.16	9	A	Rime
12-15	N	[illegible]	0.42	15	E	Rime
	N	10	0.36	18	A	Rime
	N	8	0.15	12	B	Rime
	N	8	0.04	7	A	Rime
12-16	N	-2	0.45	12	A	Rime
	N	-2	0.41	12	A	Rime
12-25	S	10	0.22	11	A	Rime
	S	10	0.35	10	D	Rime
1954						
1-4	S	23	0.25	15	A	Rime
	S	23	0.25	21	A	Rime
1-6	S	24	0.52			LWC Estimated, Clear
1-7	N	2	0.32	24	A	Rime
	N	4	0.40	30	A	Rime
	N	7	0.15	25	A	Rime
	N	0	0.26			LWC Estimated, Rime
1-9	N	13	0.64	17	B	Rime
	N	14	0.60	17	C	Clear
	N	12	0.65	16	D	Clear
1-15	S	7	0.32	8	D	Rime
	S	7	0.25	12	A	Rime
	N	8	0.28	8	C	Rime
	N	7	0.31	8	D	Rime
	N	6	0.35	7	D	Rime
1-16	N	14	0.33	11	B	Rime
	N	14	0.31	9	D	Rime

TABLE 2 (Continued)

DATE	TEST STAND	TEMP (°F)	LWC (gm/m^3)	DROP DIAMETER (microns)	DIST TYPE	REMARKS
1954						
1-16	N	14	0.42	11	D	Rime
1-20	N	28	0.43	11	A	Clear
	N	30	0.35	11	A	Clear
1-25	S	20	0.13	16	A	Rime
1-26	S	26	0.38	16	A	Clear
1-27	S	20	0.10			LWC Estimated, Clear
2-4	N	26	0.47	8	C	Clear
	N	26	0.35	11	B	Clear
2-5	N	14	0.31	15	D	Rime
	N	14	0.30	15	A	Rime
2-8	S	5	0.15	5	B	Rime
	S	5	0.12	6	B	Rime
2-16	S	17	0.10	17	B	Rime
2-21	S	29	0.64	17	F	Clear
	S	28	0.60	17	F	Clear
	N	29	0.49	13	C	Clear
	N	29	0.51	11	F	Clear
	N	29	0.48	13	F	Clear
	N	30	0.40			LWC Estimated, Clear
	N	30	0.39	9	F	Clear
	N	30	0.48	10	F	Clear
	N	30	0.48	10	F	Clear
3-1	N	22	0.22	17	A	Rime
	N	22	0.16	17	A	Rime
	N	23	0.39	19	A	Clear
	N	22	0.34	14	J	Clear
	N	21	0.45	10	A	Clear
3-6	N	-3	0.07	12	B	Clear
3-8	N	4	0.20	10	D	Rime
	N	4	0.07	8	C	Rime
	N	4	0.17	6	E	Rime
3-10	N	16	0.33	12	A	Rime
	N	16	0.27	15	B	Rime
	N	16	0.41	10	A	Rime
	S	3	0.05	7	A	Rime
	S	3	0.05	7	A	Rime
3-15	N	8	0.23	15	B	Rime
	N	8	0.10	13	D	Rime
3-17	N	1	0.05	7	A	Rime
3-20	S	31	0.59	13	G	Clear
4-8	N	23	0.95	16	C	Clear
	N	20	0.67	11	D	Clear
4-11	S	27	0.33	16	C	Clear
	S	26	0.40	12	B	Clear
4-16	S	21	0.50	32	H	Clear
	S	21	0.67	18	A	Clear

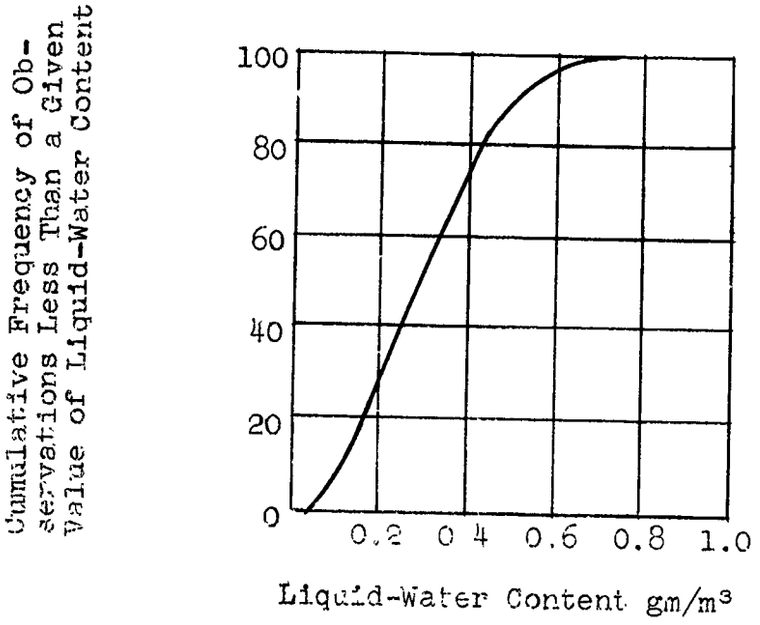

FIG. 1. Cumulative-frequency curve of 133 rotating-multicylinder observations of liquid-water content in supercooled clouds (EB-24M flight data).

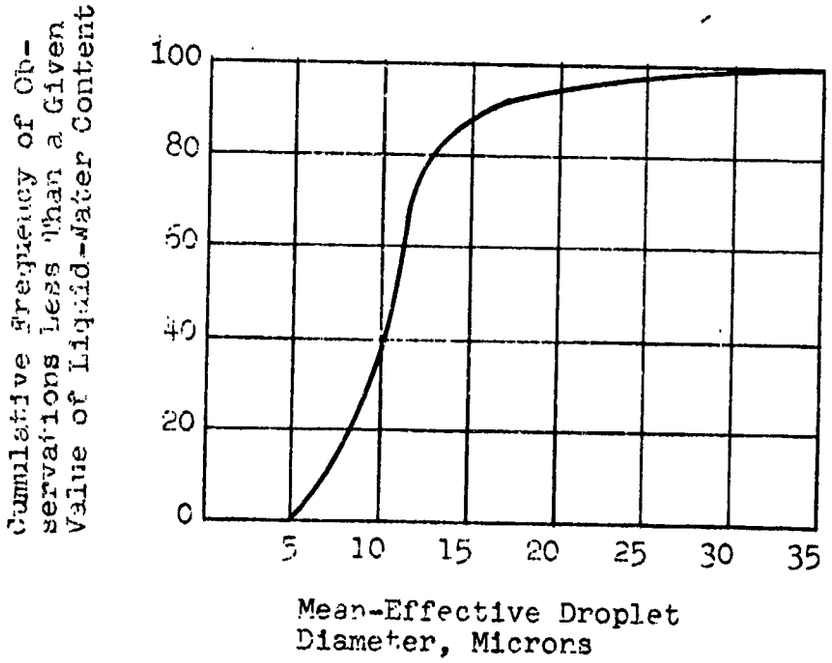

FIG. 2. Cumulative-frequency curve of 133 rotating-multicylinder observations of the mean-effective droplet diameter in supercooled clouds (EB-24M flight data).

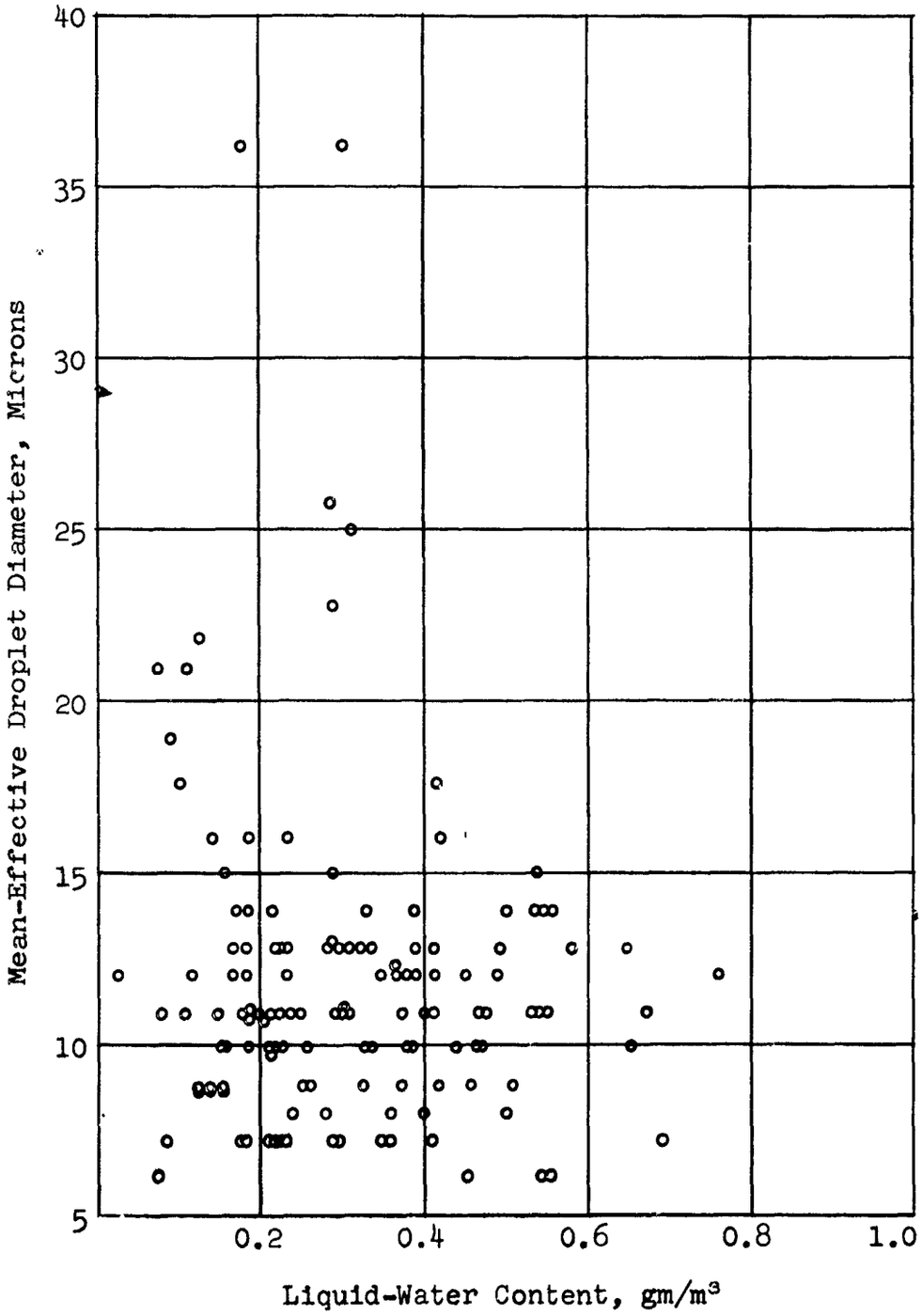

FIG. 3. Variations of liquid-water content and mean-effective droplet diameter for 133 rotating-multicylinder runs (EB-24M flight data).

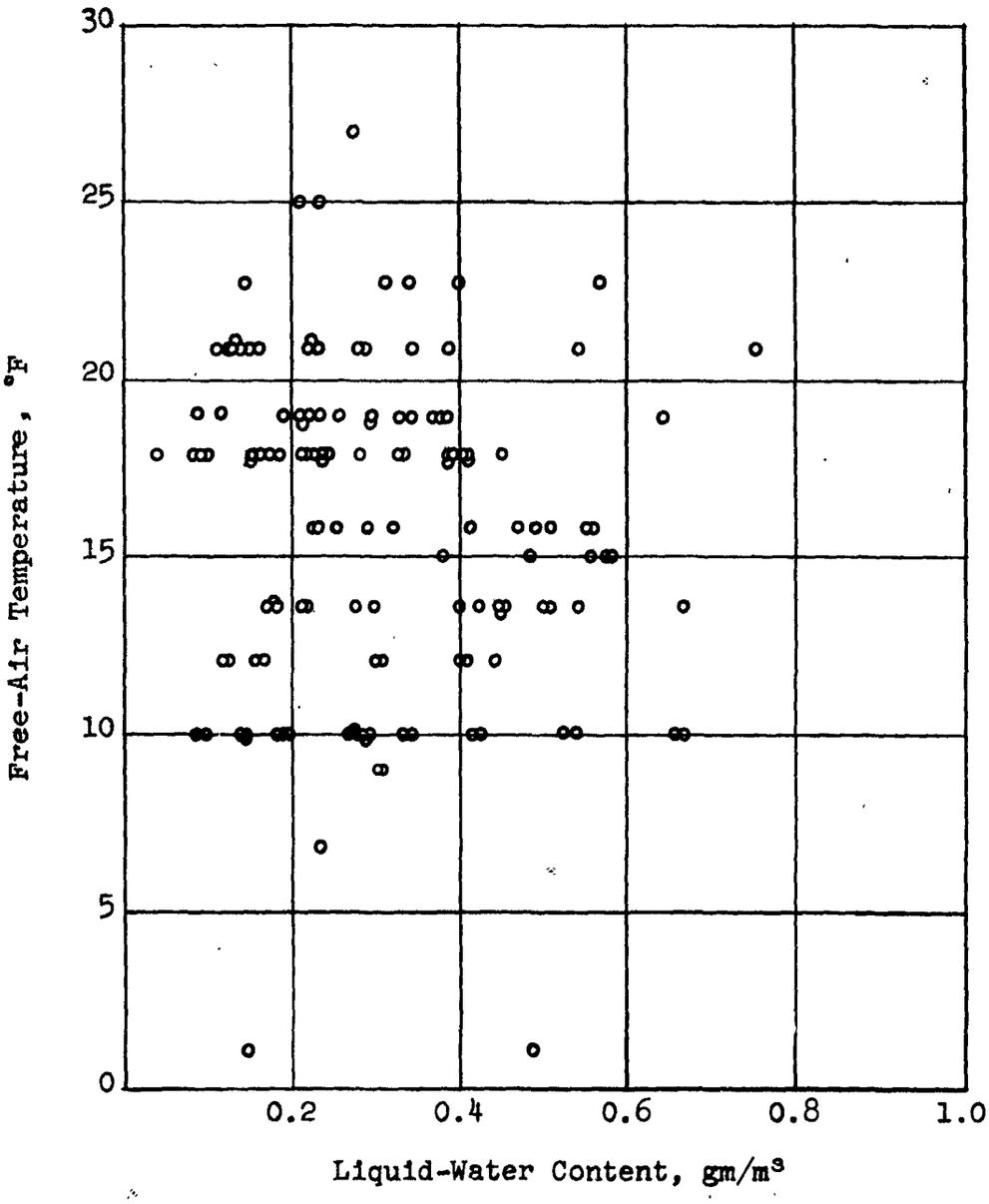

FIG. 4. Variations of liquid-water content and free-air temperature measured during rotating-multicylinder runs (EB-24M flight data).

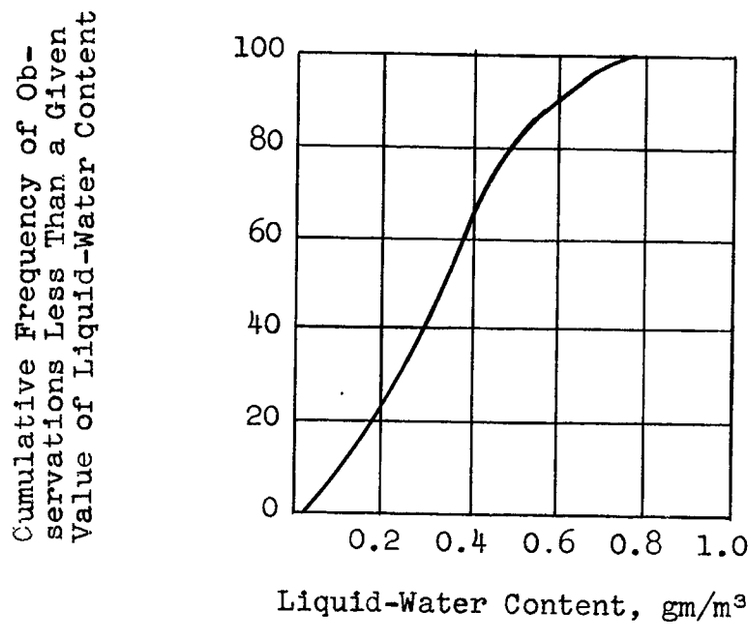

FIG. 5. Cumulative-frequency curve of 79 rotating-multicylinder observations of liquid-water content in supercooled clouds (Mt. Washington Project-Summit Data).

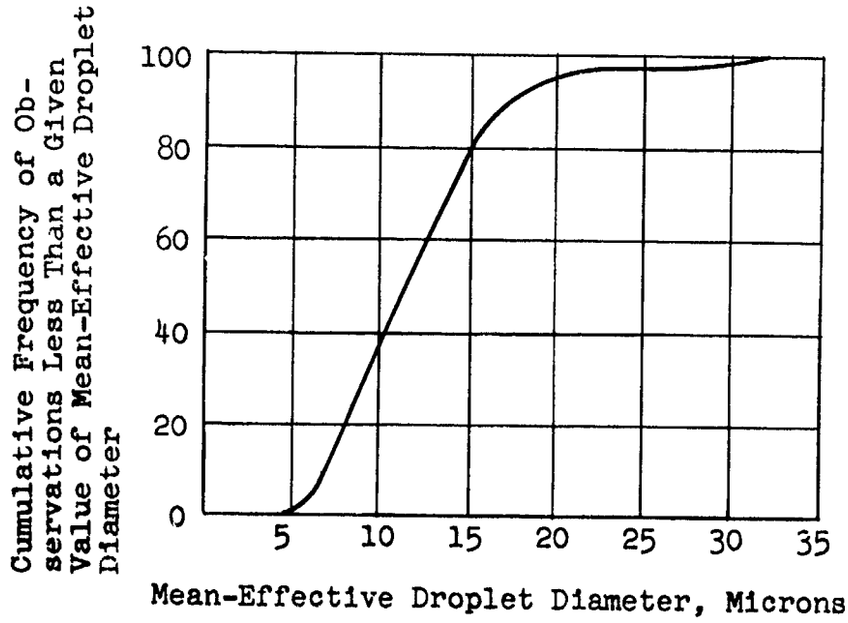

FIG. 6. Cumulative-frequency curve of 79 rotating-multicylinder observations of mean-effective droplet diameter in supercooled clouds (Mt. Washington Project-Summit Data).

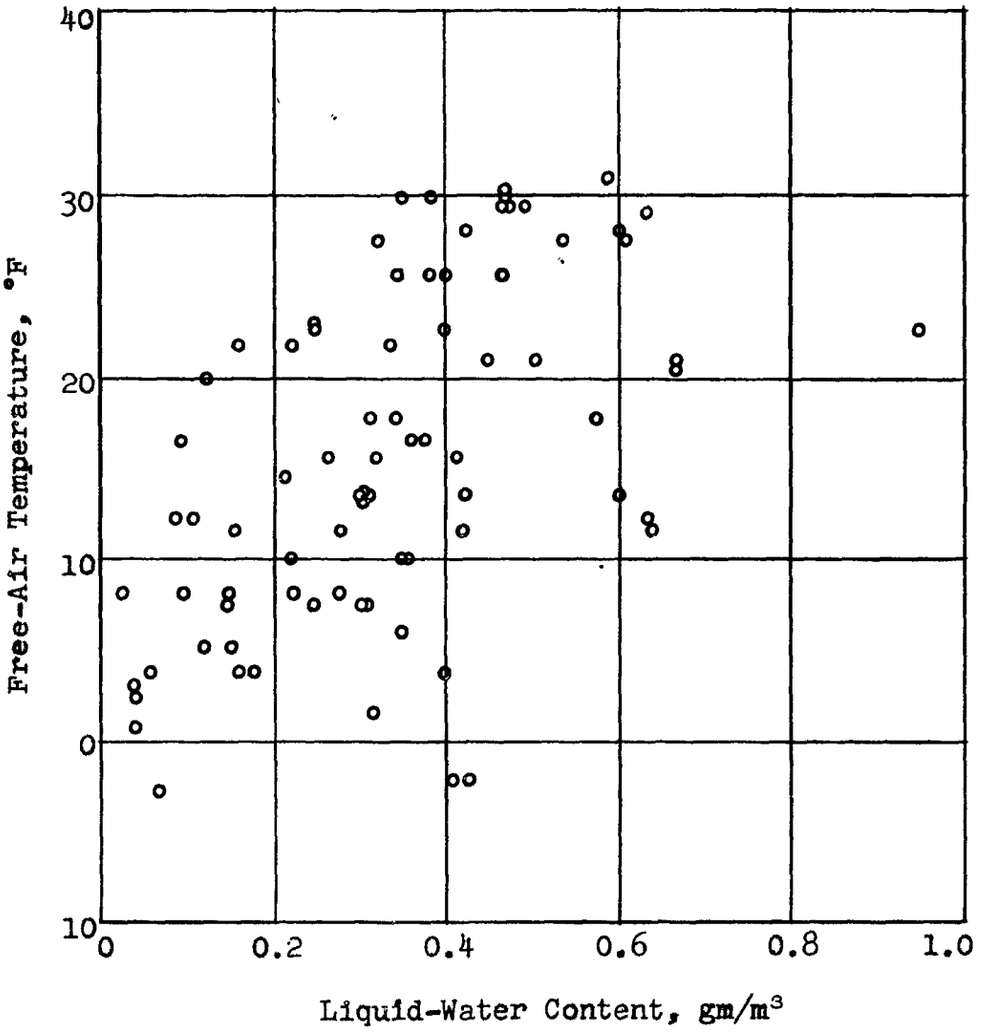

FIG. 7. Variations of liquid-water content and free-air temperature (Mt. Washington Project-Summit Data).

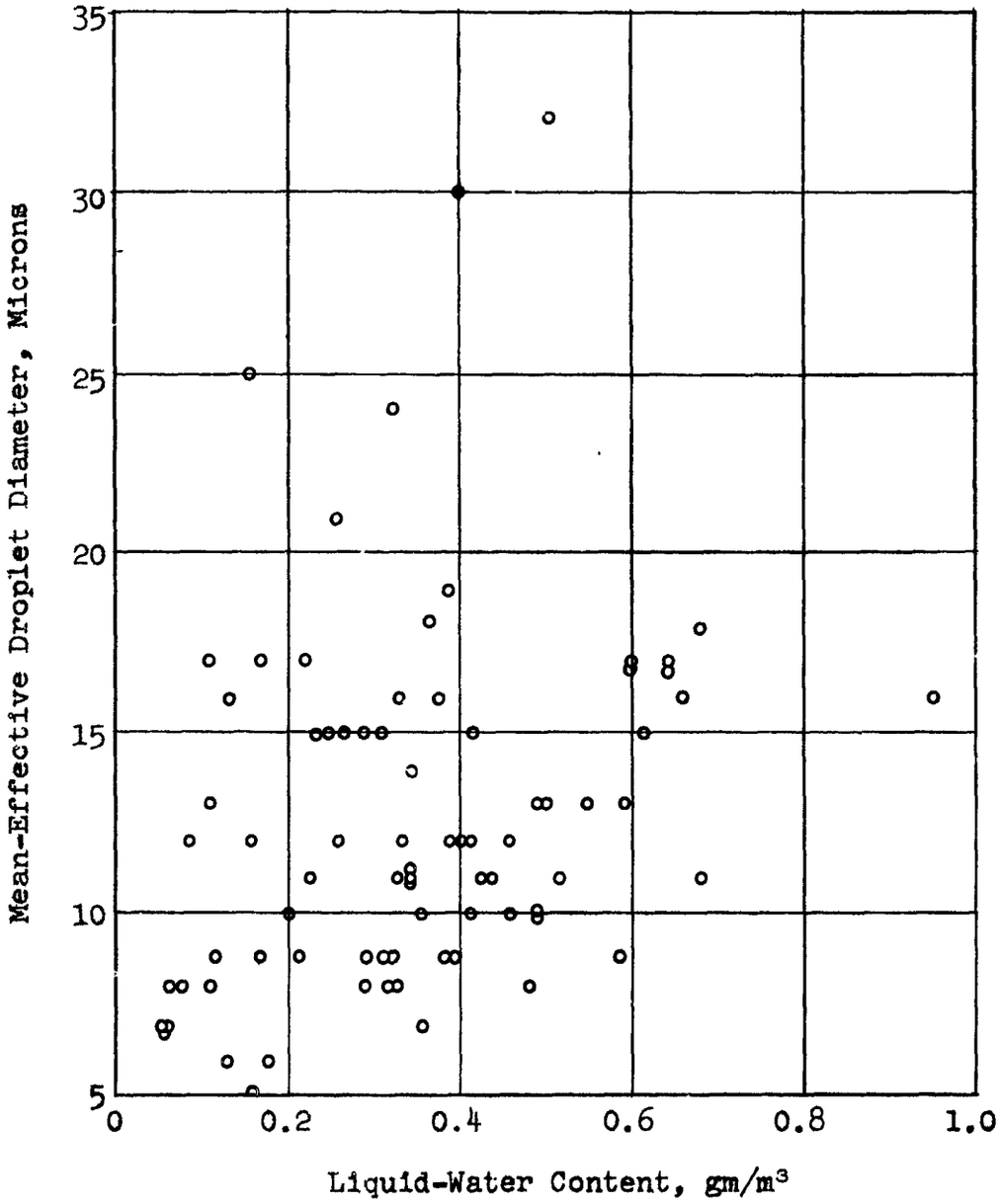

FIG. 8. Variations of liquid-water content and mean-effective droplet diameter for 79 rotating-multicylinder observations (Mt. Washington Project-Summit Data).